

COMPUTER ASSISTED INSTRUCTION

Feasibility 1976

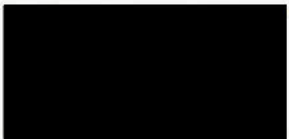
H. Kratz

COMPUTER ASSISTED INSTRUCTION

A STUDY INTO THE FEASIBILITY OF COMPUTER ASSISTED INSTRUCTION
IN THE AREA OF BASIC EDUCATION

Hans Kratz
Media & Curriculum
Field Services Branch
1976

The author wishes to acknowledge the valuable help received from Mr. N.J. Andruski, Dr. S. Hunka, Dr. D. Richards, Dr. K. Nixon and others who have assisted this report. The views expressed are those of the author and not necessarily those of Alberta Education.



AE
COM

TABLE OF CONTENTS

Introduction	1
Computer Languages & Software.	13
Economic Feasibility	19
Organizational Feasibility	29
The Human Element.	31
Teacher Preservice & Inservice	35
Concluding Statement	40
Appendix A	42
Appendix B	44
Appendix C	45
The Growth of CAI at the University of Alberta	79
Bibliography	

INTRODUCTION

Computer assisted instruction (CAI) is a substantial innovation in education. An analysis of CAI as a concept as contrasted with an analysis of existing systems suggest that it has the potential of having great impact in the educational process.

Computer assisted instruction in its simplest terms is the automotion, by data processing methods, of courses taught by conventional instruction.

The unique character of a CAI system depends on the ability of the computer to provide two significant capabilities: memory and logic. No other "aid" provides the detailed collated memory of students' responses to individual displays of instructional materials in a form that is directly useful for automatic processing. Nor does any other "aid" provide its logical capability for making the organization of instructional information dependent upon the characteristics of the individual. Memory and logic are very important but together they also provide the capability to monitor. Monitoring at an individual level could be aggregated to provide information as to how the educational system is functioning. In addition because of 'memory', instructional procedures and content must of necessity be so well defined that they form the basis from which improvements are made.

The primary objective of CAI is to simulate individualized instruction as historically seen as one learner and one teacher. The characteristics of this type of instruction are:

- a) The student can learn at a self-determined rate.
- b) The instructor can organize presentation material to the student in small unified segments according to human learning principles.

- c) The instructor can supply review of remedial material whenever the student's learning needs demand it.
- d) The instructor can repeat relationships between ideas, ordered sequences, or other complexities based on the need of the individual student.
- e) The instructor can provide various types of reinforcement immediately after the student responds correctly, thus increasing the probability that the student will later recall the answer to an instructor's question.
- f) The student can maintain a high rate of response and avoid being passive in the learning situation
- g) The student can receive feedback immediately after responding to a question. This feedback indicates whether the answer is correct or not and why it is correct or incorrect.

Feedback may be corrective, but it can also be the basis for diagnosis. There are many levels of feedback which can be designed. Again the student can be monitored and provided with a variety of approaches to the learning of his material.

The result of computer assisted instruction when done well is simply that the student learns at an individualized rate; also having a student work at a faster rate can have some effects upon the estimation of costs of his education.

The comparisons in CAI research studies clearly show significant benefits of CAI learning and training as compared with conventional instruction techniques, and these benefits are not due to chance. Students learn faster and achieve higher test scores when using CAI than they do with conventional instructional systems.

It can be claimed with reasonable confidence that the newer communications media and devices can "teach", that is, they can be expected to produce essentially equivalent learning outcomes in the form of typical student achievement when juxtaposed against more conventional forms of

instruction. Indeed, the plethora of the "no significant difference" finding in research and more recently findings of significant differences by Petruk and others on comparative instructional procedures has at least implicitly placed the burden of proof upon the traditional modes of instruction to justify their own existence. It can also be argued that, in the context of multiple manipulations of a number of inter-related instructional components, the systematic introduction of the newer technologies can well be expected to "create" new time and provide new latitudes for generating more accommodating learning environments. The 'new time' should be used to improve CAI material and work with students on an individual basis - also to do a better social job with students.

The traditional conception of the instructional role of communications media and related devices as that of an "aid" to the teacher must give way to an emerging complementary role as more direct mediators of learning, and increasingly, through independent and autonomous use by the individual learner. With this shift in orientation, a greater abundance of material and resources will be produced with substantially different formats and designs in order to accommodate such individual learner use.

Experience to date with the instructional use of the available technologies emphasizes the importance of more precise and clear articulation of learning objectives which are intended to represent the ultimate goals in a given course or curriculum. In turn, teachers are remiss if they continue to teach in the usually group-oriented ways on the expectation that defensible learning goals are being attained. There is an increasing need to introduce more discipline and systematization in the selection of teaching method and in the designing and developing of particular media themselves. The acceptance by Alberta Education of the Educational Products Information Exchange (EPIE) format for media selection should help introduce the discipline and systematization in the selection of teaching materials. The selection of teaching strategies are more conducive to learning if left to the universities to pre-service and Alberta Education and school authorities to in-service.

To be effective an instructional system needs to be capable of individualized instruction in which the product (program) itself takes the student through the material to be learned in very small logical systematic steps of presentation and responses and provides immediate feedback, depending on positive reinforcement to ensure learning.

Instructional information presented via computer can usually be classified into various modes, the most commonly used classification of modes is, from the simple to more sophisticated is problem solving, drill and practice, inquiry, simulation and gaming, tutorial and author made. Let us take a brief look at each.

1. Problem Solving

One of the CAI system modes is problem solving. This mode is readily achieved, provided the typical computational capability of the computer is available and there is a typewriter or some other display and response device, usually remote, in two-way communication with it. Each student must know a language that permits him to enter into the system both the data for his problem, and the steps which the computer must take to work out the solution.

The student needs to know how to communicate with the computer and how to solve his problem.

Problem solving is a good example where the student must become creative to the solution of a problem. This is in marked contrast to a student staying within the bounds of a defined CAI course. The teacher must give direction as to problems and approaches.

2. Drill and Practice

The second of the CAI system modes is drill and practice. In order for the student to use the CAI system in this mode, the system must be programmed to handle the particular drill and practice materials selected, or developed, by a teacher. The materials are designed to build skills and give the students the kinds of practice that the teacher feels they need to meet the minimal objectives of the course. Consequently, the drill and practice mode involves the instructional staff in the use of the computer to a much greater extent than does the problem solving mode. The student, though involved rather intensively in the use of the console, nevertheless needs to know very little about the way in which the CAI system works, since he uses his natural language, not a computer language, in order to get his job done.

Drill and practice can also form the basis for monitoring the system. Evaluation becomes continuous not restricted to formalized test periods as is current in the schools today.

This mode lends itself to perceptual motor as well as verbal memory learning.

3. Inquiry

The inquiry mode is the third type of CAI application. In this mode the CAI system responds to the student inquiry with answers it has stored in its files to the extent that the algorithms it contains provide access to that information. In this mode, the student does not need to know much about the CAI system, but the instructional staff must learn how the system operates in order to establish files and search algorithms that anticipate student questions. The amount of data stored under this mode is proportionally greater as student needs are assessed. It is an open ended approach.

4. Simulation and Gaming

A fourth mode of CAI is simulation and gaming. In this mode the instructional staff formulates a model of some real or idealized complex situation. The complex relationships among the variables that represent the situation are the aspects of the situation that the student must learn to work with and interpret. A game may not represent a particular business or interpersonal interaction. A game is a structured activity with set rules for play. It does not attempt to imitate real life situations.

A simulation, on the other hand, does attempt to represent a real situation. To implement this mode of CAI the teacher must define the model sufficiently to permit it to be programmed. A computer program must be written to process the student's input so that he gets a meaningful output. The output is determined by what the student does and by the model. The student interacts by using natural language. Simply, simulation is to represent certain features of the behaviour of a physical or abstract system by the behaviour of another system. An example is the representation of a real fractionating tower, with various temperatures and pressures being related to the products output by a computer program.

5. Tutorial Instruction

A fifth mode of CAI is tutorial instruction. In this mode the instructional staff takes responsibility for the student's instruction on the system. The logic of the instruction must be formalized and entered into the system.

The important factor here is the responsibility assumed by a teacher for the kinds of interactions which occur during the instructional

experience. The specific instructional logic to be used for a particular student will be one in which the curriculum is generated by the system, based upon information it contains about the student and about the factors that make a difference in his instruction.

The tutorial mode is not only Socratic in its dialogue with the student but it is also managerial in its use of each of the other modes as needed. In designing instruction for this mode, the instructor develops the conditions for tutorial instruction. He must also formalize his philosophy of teaching and the specific strategies he wants to use at each stage of the instructional sequence. The instructor must be sufficiently precise to allow a programmer to program the course though. The instructor must not over formalize and stick to one strategy otherwise the student will get bored.

Two families of strategies are used. In one, the set of possible conditionals is specified sequentially as data are accumulated. In the other, all conditionals are specified in advance of instruction for all learners. The actual programming or coding of the material need not be done by the author, but he needs to be able to communicate what it is he wants done to someone who has the skills.

Computers when used for teaching can provide supporting activities to teachers as well as to students. Many high-level computer languages provide the author with the means for entering and editing course materials.

Entering and editing the material is important. The efficiency of the various authoring systems are by no means the same. It is important, for example, that an author be able to immediately correct any errors in the course, even while students are using the course. It is important to note that a correction made is a correction immediately made for every student using the course.

6. Author Mode

An additional capability is called the author mode of CAI.

In the author mode, A CAI system is used to support instruction. The author in most cases must generate the text. The machine may help him format it for presentation to the student. Some systems can automatically generate some of the text like feedback - but if feedback is to be corrective then the human must still take the responsibility of generating meaningful replies. In order to build a system with this capability, instructors must identify the primitives of their instructional materials and the algorithms that can be used to generate the desired text for student use. The primitives vary with the nature of the instructional materials. For example, in generating concept learning materials for students, there might be sentence forms which have blanks in them, each of which is to be filled by a word or set of words that is inserted into the blanks by the computer according to a set of instructions. Different words must be inserted in a particular blank at different times for the same student or for different students to make up sentences with different meanings. In effect, in the author mode, the computer is used as a compiler of educational text.

More generally, authoring modes provide the author with the ability to create his material within the machine, to simulate the macro and micro instructional strategies they wish to use, to collect the data they wish, and to make modifications to the course. There is as much variation in authoring modes as there are CAI languages.

Author modes in general have the following objectives:

- a. Provide teachers, curriculum developers and training specialists with the capability of designing, producing, and delivering instructional materials geared for the needs of the local environment.

- c. Supply teachers, curriculum developers and training specialists with the flexibility to design, produce and analyze reports based on student/lesson performance data that will aid in:
 - instructional planning process
 - student guidance and counselling.
- d. Develop an instruction system which is consistent and supportive of CAI instructional technologies and principals.

SOME OBSERVATIONS:

Research done by Feldhusen and Szabo indicated that most applications of computers for instruction have involved the information transmission model of learning, while many of the curriculum development projects have stressed the information processing model in developing materials and procedures for instruction. They make an appeal for the exploitation of the unique power of the computer in providing instruction in information processing in such forms as gaming, simulation, problem solving and enquiry. While the latter areas, they suggest, are represented in CAI projects, these are nevertheless outweighed considerably in quantity by the didactic or information transmission type of programs. One of the reasons for this could be that frequently authors of these methods have never taught real children with real problems. They must be integrated into an overall instructional design which may involve drill tutorial, etc.

An example of the problem solving application of the computer is described by Hallworth in the area of mathematics where mathematics students in high school have access to a terminal and use the computer to solve problems in mathematics. In the course of the instruction, the students are introduced to a particular computer language and have access to the terminal which is attached to a time-sharing system. Hallworth reports that "it has proved possible to teach FOCAL (a computer language) to both junior and high school students with no difficulty. At both

levels, students have shown great enthusiasm and have written quite sophisticated programs." Riffel, in a mission proposal to the Alberta Human Resources Research Council on the use of computer technology in education, similarly emphasizes the advisability of the use of the computer as a problem solving tool. Hunka reports having used APL with Grade 4 children. Computer terminals for the APL project were in the schools. Currently public and separate school children are using the facilities at the University of Alberta for this activity.

It is in the daily management of instructional activities, however, where the computer's contribution has become more tangible. This mode is called the CMI mode--computer management instruction. This use of the computer takes advantage of its enormous capability for storing, retrieving and manipulating large amounts of information. The major projects referred to as exemplars, IPI Individually Prescribed Instruction, Project PLAN and TAIM, have built into their instructional systems a distinct computer capability. This is in order to make the programs feasible for implementation at the school building and classroom levels. If a student will be guided appropriately in his instructional activities in accordance with his present level of performance, abilities, aptitudes, and previous experience, teacher and learner will be compelled to examine and analyze a large amount of detailed information about learner characteristics as well as the interaction between the learner and the instructional program.

IPI and PLAN were developed in the late 60's. More recent developments include the highly promising explorations of computer assisted instruction by the University of Alberta, Division of Educational Research Services (DERS). Under the direction of Dr. Steve Hunka, DERS has developed CAI programs in education, in cooperation with Edmonton Public and Separate Systems in the teaching of French, mathematics and has introduced CARE (this course teaches elementary school teachers in the identification of handicapped conditions in children.)

The University of Calgary under Dr. Hallworth developed a workable management system for the Individually Prescribed Instruction project school in Calgary on a small computer. Since exposure here is to Graduate University students taking CAI courses, the number of students and the amount of material as well as the length varies from case to case. Also under the leadership of Dr. Hallworth students attending the Calgary computer application unit have designed a course in junior high math. A remedial reading course has been designed as well as CAI for the developmentally handicapped. Recently the computer application unit has been involved with a computer based vocational counselling system.

The Calgary computer application unit differs from the Edmonton unit so far as terminals can be placed anywhere where telephone acoustic coupling is available. The Ders computing in Edmonton is hard wired. Students come to the computer in Edmonton. In Calgary and Lethbridge the computer goes to the school where the students are located. There are some other major differences: Ders have audio, picture projection, light pens, CRT with graphics capability, many different character sets, ability to run Coursewriter and APL, which make quite a difference. These facilities are on all terminals used by students at the Edmonton Ders unit. The U of A unit is multi-sensory and thus a more effective mode for course material retention.

The University of Lethbridge under Dr. Dakin is piloting a project in mathematics in the elementary school in two Lethbridge schools. Results show the CAI in the above applications has definite impact on the improvement of learning.

Nelly McEwen (Department of Secondary Education, University of Alberta) and Arthur Robinson (Harry Ainley Composite High, Edmonton,) summarized their findings of CAI at DERS as follows:

The use of CAI has several advantages over traditional instruction. The possibility of specifying a predetermined criterion level permits all students to attain mastery of the content before continuing to the next unit. CAI provides the student with more instructional contact as well as his active involvement in the learning process at all times. The student's progress is not dependent on his classmates but rather on his own ability to learn the material. The immediate feedback given by the computer for each response allows prompt correction of errors. In essence, the computer can act as a private tutor for each student.

More description of the above is given in Appendix C.

Computer Languages

Computers operate in accord with a set of instructions programmed into the machine through codes and notations known collectively as computer languages. These languages are designed to provide the user with a convenient and appropriate means of getting the computer system to do the tasks he wishes, and to make the most economical and efficient use of the set of basic operations that the machine designer has provided. Languages are described as low-level or high-level according to whether the program statements specify computer operations in minute detail, or whether their individual code-words (which are often close to the natural mode of expression of particular users) represent a complex series of operations in the machine.

Frye lists and describes four general classifications of languages:

- 1) conventional compiler languages;
- 2) adapted conventional compiler languages;
- 3) interactive computing and display languages; and
- 4) specially devised instructional author-languages.

Class I languages include *COBOL* and *FORTRAN*. These require considerable programming experience and are seldom thought of as CAI author-languages. *Class II* languages include *CATO*, one of the extensions of *FORTRAN* developed for the earlier *PLATO* systems at the University of Illinois. *Class III* languages include *APL* and *BASIC*. These are interactive computing and display languages and have a great variety

of uses. When not used for an instructional sequence but rather to extend the student's ability to solve problems, they are referred to as belonging to CEI (Computer-Extended Instruction). The major emphasis in APL and BASIC is to develop in students the ability to program their own solutions to problems. The important thing is that APL allows a student to really explore mathematics - something which he cannot do in the classroom. Also, the student can be brought to think about operations on numbers which break (surpass) traditional operations. Class III languages have the capability to diagnose programming errors, to report them as they are encountered and to provide for immediate correction. *Class IV* languages include *COURSEWRITER*, *PLANIT*, and *TUTOR*.

Another classification that should be added to Frye's classification is NATAL 74. NRC is developing a language NATAL 74 to provide Canada with a common language to facilitate course exchange. One of the important characteristics for an authoring language is that it allow the definition of instructional strategies including diagnosis and answer analysis. More flexible languages do usually require larger machines, but the more expensive terminals are not really related to the language which one can use. The sophistication of a terminal depends to some extent on the availability of Central Processing Units (CPU) power. However, this could change quickly with the introduction of CPU circuit chips right into the terminal itself.

These languages are designed for building and administering instructional sequences. They permit in varying degree such features as: monitoring student performance and collecting student performance records, special answer-matching rules, and decision rules for guiding individual students through appropriate instructional sequences. The most flexible languages usually require the larger computers and the more expensive terminals.

Computer Software

Computer software would need to be looked at as available in the areas of need as indicated by the "Survey of Superintendents", 1967. Their responses indicated that the needs as viewed by school systems at this time appear to be in the area of basic skills development in language, reading and arithmetic.

This can be broken down further into:

- Comprehension Skills: Special problems are analyzing what is read, drawing inferences, getting the author's nuances, and figuring out analogies. Today's young people are avid readers but often cannot use what they read, being able only to retell the material in a literal-way when asked to discuss it.
- Spelling: Syllabication, short vowel sounds, digraphs, and diphthongs are trouble spots.
- Usage: Punctuation, syntax, and vocabulary are all particularly difficult for children whose home and community models are limited or non-standard.
- Study Skills: Outlining, locating information in dictionaries, encyclopedias, atlases, libraries--children who can use these resources when directed to them may be unable to determine on their own where to seek information.
- Computation: Opportunities for realistic and interesting practice, necessary to develop facility, are adequate. Consumer math skills to solve problems involved in making basic purchases.

Not being in the computer assisted industry has a disadvantage for me namely that some authors are not too willing to share programs unless they get feedback. Therefore the most lucrative source of information was the literature available.

Search of literature indicates the availability of a vast number of programs. It should be noted that few of the programs were designed for the Alberta curriculum, though some with minor changes can become part of the Alberta curriculum. Changes that need to be made are to Canadianize American or British materials.

The following programs are available:

University of Alberta DERS

Remedial Arithmetic: A course which contains both diagnostic and drill sequences in basic arithmetic skills.

French: Working on the basic design of a program which was developed for teaching reading to deaf children. This program is aimed at upper elementary and junior high school English speaking students.

Physics: An optics laboratory has been programmed for use by students in beginning physics course.

Social Studies: The French Look West - a course for Grade 7 Social Studies.

Viva: A course to teach the use of the Keyboard and light pen and to provide an introduction to the terminal to high school students.

Prack: Feasibility of teaching pre-schoolers coordination discrimination skills leading to sight reading, program durations, unlimited.

Arithmetic Drill: Grade 1. The Primary objective is to provide drill in addition and subtraction for Grade 1 children. Problems answered incorrectly are given again as a function of how well the child is doing - program duration indefinite.

Mat 20: Grade 11. The program was designed to compare the relative effectiveness of five programs: a linear (Mat 20) program and a branching program (Log 20) Course duration - 10 to 15 hours depending on students ability and progress.

Electricity and Magnetism: Grade 8. This program is intended to teach elementary concepts of magnetism, static and current electricity to Grade 8 students. Program duration - 4 to 8½ hrs. with an average time of 7 hrs to complete.

Fund: (Fundamentals of Data Processing) This course is designed as an introductory course in computer organization operation and programming. Average completion time for the course is 22 hours.

Fishy: Junior High School. Simulation game, briefly describes the importance of the salmon fishing industry. This is followed by actual simulation exercise - course duration average one hour.

Arithmetic (Research): Elementary. The program is a drill sequence in basic arithmetic operations. It was constructed as a tool for research into the transfer of learning in arithmetic. There is sufficient flexibility in the program for it to be used in a variety of research or training applications. Since the number of problems presented to a student is a variable which can be controlled by the operator when the student is registered, the sessions would most probably range from twenty to sixty minutes in length.

Drill 20: Grades 1-2. Elementary Mathematics written for the slow learner. This is a remedial and practice program with 20 levels of graduated difficulty. After each level has been completed the student is given a review on a previous level at which he had the lowest percentile score. Duration variable.

Drill 30: Grade 2-4. Elementary Mathematics written for the slow learner. This is a drill and practice program for addition of one, two and three digit numbers. The student must "copy down" the numbers to be added in the proper vertical format, and add them digit by digit. Provision is made for recording amounts to be carried. Progress through six levels is on basis of 90% criterion. Duration variable.

Drill 40: Grade 2-4. Elementary Mathematics written for the slow learner. This is a drill and practice program for subtraction of one, two and three digit numbers. The student must "copy down" the numbers to be subtracted in the proper vertical format and subtract them digit by digit. Provision is made for "borrowing". Progress through six levels is on the basis of a 90% criterion. Duration variable - 6 levels and 10 questions per level minimum.

University of Calgary

Junior High School Mathematics Basic Skills.

Several Programs for Mentally Handicapped

e.g. Money

Recognition of Shapes

A program aimed at reading readiness. A program
that teaches reading.

Teachers produce programs to fit their own needs as they work through
courses at graduate level.

A compendium of computer programs produced outside of Alberta is given
in Appendix D.

ECONOMIC FEASIBILITY

The value of a computer assisted instruction system to education has two possible aspects. If such a system is to be regarded as adding something entirely new to education, an extra quality or quantity of learning which cannot be achieved in any other way, then the appropriate measure of its value is the cost of the other things, inside or outside education, that society is prepared to forego in order to have this new thing. Benefits of this sort seem possible in special application, such as the education of handicapped children. The technical capabilities of computer assisted instruction systems has become clearer, thus prospective benefits of this kind appear on a larger scale.

In the present state of knowledge, it seems that the other approach to the evaluation of computer assisted instruction, treating it as a substitute for some of the traditional types of goods and services fed into the education system, will be likely to be more generally appropriate. The remainder of this chapter concentrates on this point.

Fritz indicates that computer assisted systems are not going to be introduced in place of a large slice of existing teaching capacity. Rather they will enter the system at the margin, sometimes instead of seeking for extra staff or equipment that has proved difficult to obtain. In economic terms, the introduction of computer assisted instruction will be justified if (and only if) it is likely to do the job as effectively and more cheaply than these alternatives. The effectiveness of the computer as an imparter of knowledge has been proven in research all over the world. In Alberta, Drs. Hunka, Petruk among many researchers have found significant difference in CAI over the conventional teaching mode especially in the areas of development of skills and transmittal of data.

The most that can be attempted in this report is a comparison of the present average costs per student hour and those for computerized systems. The use of this exercise is solely to arrive at a first estimate of orders of magnitude; so that the decision on whether or not to invest in research and development of computer assisted instruction can be taken in the context of the likely ultimate benefit. It is important to remember that no suggestion is made that if computer assisted instruction shows a lower cost, it should displace conventional teaching methods.

Cost of Conventional Teaching

The following information is available from Alberta Education and is the basis of calculations.

Average number of teaching days: 185.

Average length of school day: 5 hours

Average cost of providing a year of education in Alberta schools was \$1,181.95 in 1974-75.

The costs of not attaining desired behaviors in students is not assessed.

Thus by using this formula:

The average number of teaching days X average length of school day = number of hours students are taught.

1974-75: $185 \times 5 = 925$ hours.

$925 \times 60 =$ number of minutes. 55,500 minutes of instruction.

Average cost of
providing a year of
education

$$\frac{\text{Number of hours}}{\text{Average cost of providing a year of education}} = \text{cost per hour per pupil} \times 60 = \text{cost per minute per pupil.}$$

$$\frac{1,185.95}{925} = \$1.28$$

$128 \div 60 = \$0.02$ per minute

Cost of Computer Assisted Instruction

The costs of a computer assisted system may be divided into four categories: hardware; systems software; educational software; operating costs. The first three categories are in the nature of capital cost; the latter is a recurrent cost and includes administration and maintenance. To arrive at a common basis for comparison these costs must be converted to probable costs per student hour over the expected operating life of the system.

A computer assisted system is not necessarily constrained by the 9:00 a.m. - 4:00 p.m. syndrome and, in fact, is capable of round-the-clock operation. In the analysis that follows it is assumed that the system is fully loaded for at least 2000 hours per year since, as in any capital intensive system it will be more cost effective the greater its intensity of use. It should be noted here that the DERS computer system is now operating at 4000 hours per year.

Hardware Costs

Hardware costs are relative to the size-type of the system being installed whether it is being purchased by cash, leased to purchase, lease or rental.

Terminals

a. CRT type (Cathode Ray Tube)

CRT are usually more costly than teleprinters today. Also the terminal usually interacts with the CPU through some buffering control circuitry and not directly with the CPU (Central Processing Unit). A terminal is much too slow to be allowed to hold up the CPU. The CRT has capability for drawings and special character sets.

b. Teleprinter (vary in speed--median speed 300 B.P.S.)

Lower cost than CRT type with generally the same capabilities excepting that a written copy of information or record is available. Maintenance and overhead is generally higher due to the cost of paper products. This teleprinting needs to interact with buffering control circuit. It is usually noisy, has fixed characters and is not capable of drawings. It is also susceptible to mechanical failure.

c. Portable Data Terminal

This terminal is of the teleprinter variety. It's prime advantage is its portability, e.g., moving from classroom to classroom; school to school.

It can be used with an acoustic coupler to any telephone set. It should be noted that for this terminal to function, data transmission must be two way and thus is accomplished by voice coupling on the terminal as well as a couple installed at the central processing unit. Some operate on an echo from the computer to confirm what was typed others do not. Clean lines are required. It is buffered from CPU with special telecommunications equipment designed for digital transmission.

All of the above require access to fairly comprehensive central processing units.

One of the most exciting events to occur in the last few years was the introduction by IBM and Digital Equipment Corporation of the mini computer. The Digital Equipment Corporation classic is under \$10,000.00 original cost. Probably the most important key to the low cost of digital's education model is the company's large library of PDP eight programs. It should be noted that most of the programs available are available through Digital or can be used on their mini computer.

The mini computers are stand above units and do not require access to a fairly comprehensive central processing unit since they incorporate a computer, a CRT, a keyboard, a printer and a floppy disk magnetic memory. They do not as yet have voice capabilities or other visual display.

Usually the larger the unit, the more terminals one can hook to and access to a CPU the more economical the system. This holds true of large installations as Montgomery County, Philadelphia Public Schools or City of Chicago Board of Education. See diagram, Appendix B.

The economy is achieved in the total number of students served and thus brings the per pupil cost down, (e.g., Montgomery County has 120,000 students.) No Alberta school jurisdiction has this number of students. Some of the larger Alberta jurisdictions would find that mode beneficial.

Due to the low initial capital cost and availability of material, I shall also compute the costs of the mini computers as a comparison.

EXAMPLE I

Model DMSI GA

Classic System

Cash cost \$8,720

Amortisized over 5 year annual payment of \$2,229 per year

Operational capability 24 hours a day.

One student at a time.

EXAMPLE II

Model 11VO3

Multi user CAI System

Cash cost simultaneously - \$20,629

Amortized over 5 year annual payment of \$5,312 per year

Operational capability 24 hour a day

Four students simultaneously.

The above computer assisted installation operates only 2000 hours per year. Thus capital cost would be if we assume a five year lease to purchase plan.

$$\text{EXAMPLE I } \frac{2229}{2000} = \$1.11 \text{ per student per hour.}$$

EXAMPLE II - Since there are four terminals, the capacity would be four times.

$$\text{Therefore, capital cost } \frac{5312}{2000 \times 4} = 66 \text{ cents per student hour.}$$

EXAMPLE III

Capital expenditure in large CAI networks includes the cost of the computer, terminals and controllers. Computers with a primary memory system in the order of 750,000 characters and a disk system of approximately 1,000 million characters would cost approximately \$1,720,000. The CPU must also have disc storage and magnetic tape drivers, card reader and communication control to be able to handle configuration of local terminals, remote single terminals, local terminal cluster as well as remote terminal clusters. In total, it would be able to handle 200 terminals simultaneously and give each the ability to communicate independently with the computer.

Terminals on large computers usually contain the following characteristics if they are to offer the greatest CAI flexibility:

- 1) CRT display which is addressable (i.e., displays can be made to a specified portion or area of the screen).
- 2) The terminal can handle a wide variety of character sets by storage of a dot pattern.
- 3) Prompt response can be made by the learner.
- 4) A visual projection system using students photographic media such as film, preferably rear screen, capable of handling slide as well as film.
- 5) An audio system by which high quality audio can be played.

This type of terminal costs in the vicinity of \$8,000 per terminal. It is a very flexible system since additional displays are available (e.g. visual and audio as well as pointing response). Terminals with less features cost less but are also less flexible and thus tend to be less effective.

Total cost of this mode including communication controllers would be \$3,520,000 cost per pupil.

$$\frac{\$3,520,000 - 5 \text{ Yrs amortization}}{2000 \text{ hrs} \times 200 \text{ terminals}} = \$1.67 \text{ per student hour.}$$

The University of Calgary reports a cost of 50 cents to \$1.50 per student hour, the differential being supervision costs bring cost up \$1.00 per hour. These costs reflect remote terminal costs only.

Educational Software Costs

Educational software costs vary with the extent of the program, the amount of residual fee charged, the material that information is stored on, as well as peripheral material available.

Prices range from \$3.00 for textual material through about \$400 for one package including the floppy disks for mini computer (example I and II) to rental of all software at \$5,000 per year (example III). The number of programs used would determine the cost.

The minimum amount that would have to be expended to get a start in developing skills in language reading and arithmetic would be dependent on the exact needs of a particular school system. It is difficult to state an exact dollar figure since needs would change from jurisdiction to jurisdiction.

Assuming that the needs were in the development of computing skills in mathematics then the following could serve. Classics T.M. Curriculum Mathematics Package QUEO3 - PZ at \$35 could be used. This package contains a selection of texts and resources and a curriculum guide for use in a variety of mathematics applications.

The closest to reality than can be stated is to look at the complexity of the program. If the program is textual in nature its costs from \$3.00 to \$15.00 averaging at \$6.00. If the material has stored material on floppy discs or tape then price is up to about \$100 to \$1000 per package depending on the number of discs and tapes included.

If other factors enter the picture such as remote video, slide and film display as well as audio capability, then rental for \$5,000 per year for multi programs is considered inexpensive. It is usually the number of programs used and usable that determine the type of equipment needed and thus the total cost.

Maintenance Costs

The division of educational research services of the Faculty of Education, University of Alberta estimates that a computer with 200 terminals would cost \$259,000 to maintain over a five year period. If these were computed hourly the per student cost would be divided by 2000 hours per year x 200 terminals x 5 years or 26 cents per student hour. The 26 cents per student hour represents maintenance under ideal conditions in house.

Maintenance on the classic system PMSIGA is computed at 67 cents per student hour. Maintenance on the IIVO3 is rated at 39 cents per student hour.

Operation of a computer network involves a staff which can direct, evaluate, analyze, program, operate, and catalogue. All of these functions indicate separate expertise. In larger establishments these functions would be done by separate specialized personnel.

In smaller establishments greater stress or reliance would be placed on "canned" material due to the lack of familiarization by classroom teachers in the field of CAI.

A Summary of Costs: The following table lists the costs as illustrated in the above paragraphs:

	<u>Example I DMSI GA</u>	<u>Example II IIVO3</u>	<u>Example III DERS</u>
CAPITAL	\$1.11	.66	\$1.76
SOFTWARE	\$1.54 per student	.40 per student*	.01*
MAINTENANCE	<u>.67</u>	<u>.39</u>	<u>.26</u>
TOTAL PER STUDENT HOUR COST	\$1.93	\$1.45	\$2.03

*Using a \$300 material package.

The above do not include staff costs or environmental costs.

Some Observations

If skills are what we want to impart, computers can do this at about the same cost as basic education is costing us now, only they can do it with greater patience (computers have no emotion) without tiring, and with greater individual attention, than any human being. We should then look more seriously at computers doing that which they can do best and that is supply data, drill and simulate on an impersonal basis.

The examples above are not equal. A system as flexible as Example III can not be really compared equally to systems (i.e. Example I and II) which lack visual display of film, audio or video accession and display capability, programs for young children, as would be needed in the reading area, a fast system with sophisticated terminals is needed. Determining the worth of these desirable features rests with the system planning use of CAI and will be dependent on its specified user needs.

In purely economic terms therefore it can be said that computer assisted instruction is not entirely to be dismissed as an unjustifiable expense, particularly since there is demonstrated proof that in some modes CAI exceeds the traditional mode of teaching. What needs to be worked out is differentiated roles. Computers should be used to do that which they can do best and teachers should take on a more facilitative human role. Teachers also become more cognizant in the development of programs for computer assisted instruction.

ORGANIZATIONAL FEASIBILITY

The structure of our educational system and how it could be affected by CAI is beyond our present imagination. In estimating the effect that CAI might have on our method of organized education one must say at the start that confident predictions are neither possible nor desirable. However, speculation can be useful for it can make it cognizant of factor which otherwise would be overlooked.

Five factors exist now which are bringing about changes in our schools, they are:

- the demand for more individual attention for the student.
- the demand for more economic use of both human and physical resources.
- the demand for higher levels of quality at all levels and with all types of students.
- the demand for equalization of opportunities.
- the need to monitor student progress.

Computers can be expected to play an important part in helping education to adjust itself organizationally by responding to the demands placed upon itself.

Computer Assisted Instruction can affect parents as well since terminals can be remoted and thus break open the classroom door. Also parents can more readily see results of their students in the ordinary school mode. The one important aspect that needs definite and close consideration is to ensure that teachers are involved in, and do take part in, new ventures that increase their productivity as teachers. Teachers would resist technology and CAI if the technology appears to direct them. Administrations need to be sensitive to be able to enhance

positive response when introducing new technology to education.

Another facet of this problem is the creation of programs of studies to be used by teachers and students that can meet specified curriculum needs. Through the use of proper evaluative constructs learner verification of these programs can be accomplished. People involved in the creation of programs would be teachers, students, university scholars and computer specialists. If programs are to get off the ground an atmosphere where the above can cooperate in harmony would need to be established and sustained.

The computer's enormous capacity for storing and displaying information and its ability to adjust sensitively and logically to new information including performance reading would indicate the need for educators to set attainable goals, establish objectives and define content (i.e., put it into parameters of scope and sequence). Educators would need to establish realistic evaluative criteria and make provision for learner verification of programs.

Bluntly, educators would need to become more precise. Systematic analysis by educators would point out the critical path through a body of knowledge.

The computer lends itself to equalizing opportunity. It is patient, tireless, non sectarian, non racists and can adjust itself to the pace of each individual.

THE HUMAN ELEMENT

The human element enters the CAI mode in at least three ways. For example:

1. as the receiver of the information;
2. as the programmer of the information; or
3. as the outsider looking on at the process.

The receiver usually already socialized, once he becomes cognizant of the operation of the computer, relates rather well to it. Petruk measured attitudes of students towards CAI using a 20 item likert-type scale. In general, attitudes were very positive. (Appendix A)

Feldman and Sears did an exploratory study of the effects of CAI on the classroom behaviour of young children. Their samples included 45 first grade children enrolled in a CAI reading or CAI math program. All of the children were from low income families. Feldman and Sears have the following observations:

"The differences between treatments, the small sample, the exploratory nature of research, and the other limitations previously mentioned, cause us to reiterate our caution in interpreting the results of the study. The conclusions are at best guides to hypotheses for future research. Nonetheless, the decrease in social behaviour for children receiving CAI instruction does suggest that critics may have some justification for suggesting that CAI leads to more sedentary, constricted behaviour (e.g., Hilgard, 1964). On the other hand, claims that CAI individualizes instruction have also been given support in this study, with the finding that correlations between behaviour and achievement are less in the subject in which CAI instruction was given."

Hunka makes the following observation:

"On the basis of our statistics course which takes an average of 80 hours we have noticed that students become very ego involved. They soon expect to get 100% on examinations. Their level of aspiration is very much higher than in the normal classroom."

Due to the datedness of the research available at the time of this report, some CAI users in Alberta were called to ascertain their impressions in regard to relationships of students to CAI. The suggestion was made that student acceptance of CAI is relative to attention span, the interest level of the program and to positive attitudes of the classroom teacher. Present limited research indicates a positive approach to CAI by students. Future studies are needed that could look at this aspect of CAI in depth.

People who develop CAI programs need to be cognizant of the needs of students and classroom teachers. An excellent model is the Montgomery County Public School System under the direction of Morgan, which used the model of using teacher specialists who develop packages in conjunction with classroom teachers. These teachers act as an advisory body. Morgan reported:

The acceptance of CAI has been generally extremely favorable. There are, of course, exceptions and these are usually due to lack of skills on the part of teachers and administrators in utilizing data which has never been available to them before.

In an effort to optimize the benefits derived from CAI and at the same time meet the needs of Montgomery County students, it was necessary to make decisions regarding the emphasis of curriculum development. Three years' experience showed that the computer could assist the teacher in a number of ways, one of them being the development of basic skills. Long-range and comparative studies further supported this view. Thus the program emphasized acquiring and developing basic skills in specific areas such as reading, arithmetic, and phonics at the elementary level and mathematics skills at the secondary level. To execute this philosophy, it was evident that the program must have wide usage of curriculum materials in a variety of situations. In addition, experience had shown that CAI was most effective when it involved faculty, department heads, and local school administrators were committed to meeting individual needs of students and providing individualized instruction. Such an educational philosophy drastically changes the roles of both student and teacher. The teacher becomes the manager of the instructional process, providing counselling and guidance to assist the student in reaching his desired objective. Meanwhile, the student becomes more responsible for his own learning in a program that has been tailored to meet his own individual needs.

It should be pointed out that Montgomery County has involved educators in designing, developing, conducting, validating and documenting courses. Montgomery has an intensive program in the description of the role of the classroom teaching in the CAI equipped school system. Montgomery County also has a good communication network in trying to communicate "what is" to all concerned.

A major concern here for universities would seem to be the preservicing of teachers so that they can fit the role of curriculum developers using the CAI mode. Hunka has a proposal to bring teachers to university, train them, help them construct material to fit their needs, and then send them back to classrooms with terminals.

Chicago, Montgomery County, Philadelphia has an intensive orientation program. These programs are geared to specific audiences such as school board members, chief administrators, principals, participants in subject and skill area workshop teachers and students. Usually

two day workshops are planned to make staff aware of CAI and its potential. Resenthal of the Board of Education, Chicago, reports very favorable teacher response to CAI.

It is felt that involvement of all teaching staff in CAI is important to ensure success. Human fear is caused by lack of knowledge of the unknown. Involvement in decision making ensures cooperation.

The role definition of CAI programmers, the facilitative role of teachers needs to be enunciated in an orientation program that needs to take place prior to the actual implementation of CAI in any school system.

It can be safely stated that teachers in general are very favorably inclined towards CAI. Teachers are favorably inclined towards CAI when the CAI is good, i.e., students are learning and the teachers are acting as real specialists.

TEACHER PRESERVICE AND INSERVICE

Preservice

Most universities in Alberta have a good curriculum and instruction program. The university offering the most courses in curriculum and instruction is the University of Alberta.

The curriculum instruction courses help teachers in designing and evaluating what it is they are to teach. It enables new teachers to be able to distinguish between the various design constructs of teaching material. The scope of the courses are mainly geared towards print media. Very little input is given to the non-print, the electronic media and little is mentioned about computer assisted instruction.

Added to this dilemma is the fact that the minimum full course equivalent that must be taken in curriculum and instruction by a bachelor of education student is the equivalent of one full course (six credits). The maximum allowed is four full courses (24 credits). The minimum total credits is 90, or 15 full courses. It is this authors contention that if we are to get serious about defining what we teach, how we teach and who we teach it to we must put greater emphasis on more curriculum and instruction courses allowing teachers to go into greater depth.

Instruction is a very complex process involving psychological and logical ordering of curriculum, instructional strategies, motivation, reviews, drills, tutorials etc. No one is forcing the integration of these factors for the one criterion of student learning. CAI forces these to integrate.

Courses available dealing with computers at the University of Alberta Computing Services are:

- a) Use of terminals
- b) Introduction to text editing and formatting

Both of these courses are available from computing services and both are non-credit courses. Undergraduate courses in educational application of computers are offered at the University of Alberta in the Department of Educational Psychology. Undergraduate courses are:

Educational Psychology 479 - Introduction to Computer Assisted Instruction.

Educational Psychology 481 - Problems in Implementation and Evaluation of Computer Based Instructional Systems.

The University of Calgary has one undergraduate course Educational Psychology 521 called Application of Computers in Education I.

The University of Calgary offers several graduate courses namely:

- Educational Psychology 634 - Computer Application in Education I
- Educational Psychology 644 - Application of Computers in Education II
- Educational Psychology 734 - Advanced Study of Computers in Education I
- Educational Psychology 744 - Advanced Study of Computers in Education II

Graduate students in the University of Calgary do practical computer work in Educational Psychology 634 if they are practicing teachers by taking a terminal into their school and thus their students have access to the university computer.

It would appear that the University of Alberta offers more courses at the undergraduate level whereas University of Calgary offers courses more at the graduate level.

It is felt that in order to get greater enrolments and be able to expand the number of courses offered in computer application and design a greater selling job is needed to ensure that education students are aware of the existence of such courses.

At present, the universities (Alberta) are doing an inadequate job of preservicing teachers for the technological break-throughs that are current, let alone guiding them to be innovative to be able to cope with future technological break-throughs.

Lack of Universities involvement in preservice probably explains why computers in public schools were and are just used for a administrative (bookkeeping) functions.

Hunka addresses the dilemma stating:

"It is hard to get the importance of computers across to student teachers when there are no computers available to them when they get into schools. We happen to think that if a teacher can prepare good CAI material that their regular classroom teaching will improve."

Inservice

There is very little done on an inservice level in regards to application of computers in education. The universities Department of Educational Research do not have large enough staffs to do much inservice. Most inservice done here is of a orientation nature to make teachers and

administrators aware of what computer assisted instruction is. Limited inservice occurs with staffs in schools where the University of Calgary has placed computer terminals. The Alberta Teachers Association Professional Development section is involved through some of its specialist councils in curricular design. (e.g. Social Studies Specialist Council).

Alberta Education is involved through its Regional Offices in disseminating information to school, administrators, trustees and teacher groups. Commercial courses are offered by various concerns mostly dealing with computers in commercial and industrial application.

It would seem that once computer assisted instruction got established in the province that there would be a real need for inservice. At present it must be conceded that computer assisted instruction has not been a priority item with many school jurisdictions, but then scientific knowledge especially space technology was not a high priority item with western nations until Sputnik.

It would appear that technology is ahead of educational practice. There are various modes of narrowing the gap. One mode would be to intensify the preservice in computer assisted instruction design and application courses.

Another mode would be a process of computer assisted program development carried on by teachers who have had curricular design background and would acquire the knowledge of computer assisted instruction via inservice and supportive facilitation, coordination and consultation by the universities, the ATA, the ASTA and Alberta Education.

The later mode has had great success in the project Canada West and more recently in the Canadian Studies Social Studies Program. Both projects were under the direction of Dr. Ralph Sabey, Alberta Education. Another alternative is to take good experienced teachers and train them to use the computer to simulate what is best in their instruction.

Another mode that shows promise is one carried on by Hallworth and his students. This project involves the programming of the Alberta Senior High Mathematics for computer. As the programs in the project becomes learner verified they should prove invaluable since they could be introduced with relatively little inservice which could occur through the auspices of the Mathematics Council of the ATA or Alberta Education.

CONCLUDING STATEMENT

In order for CAI to work well programs need to be available at the level of local need. This means that needs are properly identified, programmers are cognizant of learner needs at various levels. Cooperating teachers should be involved in keeping the program learner - verified at all times. There are quite a number of programs available for an introduction to CAI. The adaption of these as well as the construction of CAI programs that fill the needs of Alberta education would need to be of high priority if CAI is to be effective in supplying data and skills of some of the curriculum.

We have in this paper indicated that computer assisted instruction is technically feasible, economically feasible and administratively feasible. What it will require is for a school jurisdiction to be innovative enough to apply the modern technology to education and thus bring education up to date vis a vis technology.

Universities will need to take more seriously their own pre-service role especially curriculum and instructional design.

The preservice of teachers for the utilization of CAI is a crucial issue. The Division of Educational Research Services under Dr. Steve Hunka and the computer applications unit under Dr. H. Hallworth are among the prerunners in North America in the development of CAI programs. However, the number of teachers in training who avail themselves of courses offered at the universities is very small.

The reason for the success of such applications as Montgomery County is due to an excellent preservice, inservice and communications program. CAI in Alberta will not be fully successful until Alberta universities produce a significant number of graduates who have computer assisted instruction expertise.

Licklider had an inkling of what could come when he said:

" . . . preliminary analysis of technical and scientific creative activity suggests that such activity consists of short intervals of insight, invention, and decision making interspersed among long intervals of 'staff operations'. Most of the student's time is spent in getting into position to take a step, and only a small part of it is spent in taking the step. No one knows what it would do to a creative brain to think creatively continuously."

APPENDIX A

Table 7

Frequency of Response on the Student
Attitude Towards CAI Scale.

NR = No Response

D = Disagree

A = Agree

SD = Strongly Disagree

U = Undecided

SA = Strongly Agree

	<u>NR</u>	<u>SD</u>	<u>D</u>	<u>U</u>	<u>A</u>	<u>SA</u>
1. Computers may be good for teaching some things but not electrical theory.		11	2			
2. I wish our other courses would be taught by computers.				1	8	4
3. A teacher understands my learning problems better than the computer.		1	4	6	2	
4. I get worn out or fed up working on the terminal.		2	10		1	
5. I would like to take the 2nd year theory on this system.	1				4	8
6. You never know what is expected of you by the computer.		4	5	1	2	1
7. A teacher can explain things better than a computer.			5	2	5	1
8. When the teacher in a classroom asks me a question that I can't answer, I get embarrassed.			4		7	2
9. I like computer assisted instruction.		1	1		3	8
10. I think I am learning the theory better on the CAI system than if I was in a classroom with 30 other people.					4	9
11. When I don't understand somethings, the computer is more patient about explaining the problem than a teacher is.		1	3	2	5	2
12. The computer forces me to concentrate more.			1		7	5
13. I like to be able to ask a teacher a question when I don't understand something but I can't do that with the computer.			1	2	8	2
14. When you work on this system, you never know where you are in comparison to the rest of the class.	1	1	8		3	
15. I feel more at ease in a regular classroom with a teacher.		4	6		2	1
16. I'd like more practice problems on the computer.	1		2	3	6	1

	<u>NR</u>	<u>SD</u>	<u>D</u>	<u>U</u>	<u>A</u>	<u>SA</u>
17. If a friend told me he was thinking about taking this course on the computer, I would encourage him to take it.					6	7
18. I don't like learning by computer.		10	3			
19. The computer lets me go at my own speed.				1	6	6
20. If I could do this all over, I would rather take the theory at N.A.I.T.		9	4			

A Compendium of Computer Software

Multiple Choice Quiz

DESCRIPTION: A program designed for administering a multiple choice quiz with immediate feedback to the student.

MINIMUM
EDUCATION LEVEL: All

LANGUAGE: Basic

DEVELOPED ON: 8K PDP-8, teletype

DEVELOPED BY: Kenneth Lubar
Harriton High School
Rosemont, PA

AVAILABILITY: DECUS
Order # BASIC8-27

Elementary Level Instructional Programs

DESCRIPTION: A series of 17 instructional programs designed as supplemental instructional material for elementary school reading and math curricula, but additionally can be used for remedial or review work for older age groups.

ADDITI - Adding numbers in columns.

SUB - Subtracting numbers.

FLASHA - Addition of small numbers within a time limit, giving a "flash card" experience.

FLASHM - Multiplication of small numbers within a time limit, giving a "flash card" experience.

MULT - Multiplication of small or large numbers.

MULTI - Multiplication of 1-3 digit numbers by one digit numbers.

CLOCK - Helps students learn to tell time and recognize representation of time in numbers and in formal and informal words. A clock face is produced on the terminal.

INTRO - Recognizing factors of numbers.
CGF - Identifying greatest common factor.
REDUCE - Reducing fractions to lowest terms.
FRACAD - Addition of fractions with common denominators and reducing the answer.
IMPROP - Teaches difference between proper and improper fractions and conversions.
LCM - Drill on least common multiples.
UNRDCE - Drill on converting fractions to equivalent, higher denominator fractions.
UNDCEN - Adding and subtracting fractions with different denominators.
FRACMT - Multiplication of fractions.
INVRSE - Teaches and drills about inverses of given fractions.
FRACDV - Division of fractions.
FINAL - Tests student on material from all previous programs in this series.

MINIMUM
EDUCATION LEVEL: All

LANGUAGE: BASIC-PLUS

DEVELOPED ON: RSTS-11

DEVELOPED BY: Roberta A. Huntsman
Idaho Falls School District #91
Idaho Falls, Idaho

AVAILABILITY: DECUS
Order #RSTS11-44

DECAL: Digital Equipment CAI Author Language

DESCRIPTION: Digital's Computer Assisted Instruction (CAI) system is designed to enable teachers with little or no computer experience to create interactive lesson material with a minimum of effort.

MINIMUM
EDUCATION LEVEL: All levels, including adult and industrial education.

- COUNT - Practice in recognizing numbers in series.
- STORY - Word problems requiring addition or subtraction.
- ADDFRA - Concept of common denominator and drill in addition of fractions.
- PHONIC - Program for use with workbooks in the "Phonics We Use" series published by Lyons & Carnahan. Exercises include story completion, identification of suffixes or prefixes, and others.
- SPELL - Multiple choice drill allows students to pick out misspelled word.
- BLASTO - Applying additions to winning a game.
- SQUARE - Guessing game on square roots.
- CUBE - Guessing game on cube roots.
- WORD - Game in which student tries to guess a four-letter word.
- WORD3 - Game in which student tries to guess three-letter word.

MINIMUM
EDUCATION LEVEL: All

LANGUAGE: BASIC-PLUS

DEVELOPED ON: RTS-11

DEVELOPED BY: Robert A. Huntsman
Idaho Falls School District #91
Idaho Falls, Idaho

AVAILABILITY: DECUS
Order #RSTS11-43

Drill in Fractions

DESCRIPTION: A series of 12 instructional programs designed as supplemental instructional material for junior high and high school mathematics curricula, but additionally can be used for remedial or review work for older age groups.

MINIMUM
EDUCATION LEVEL: All levels, including adult & industrial education.
LANGUAGE: BASIC-PLUS
DEVELOPED ON: RSTS/E
DEVELOPED BY: Digital Equipment Corporation
AVAILABILITY: DIGITAL

Elementary Instructional Programs - Volume II

DESCRIPTION: A series of ten programs designed to supplement the elementary or junior high school instruction program, but can also be used for remedial work in high school.
MINIMUM
EDUCATION LEVEL: All
LANGUAGE: BASIC-PLUS
DEVELOPED ON: RSTS-11
DEVELOPED BY: Robert A. Huntsman
Idaho Falls School District No. 91
Idaho Falls, Idaho
AVAILABILITY: DECUS
Order # RSTS11-66

BASIC Application Programs-Business/Social Studies

DESCRIPTION: A booklet containing a series of BASIC programs for use in business and social studies curricula.
POPULATION - A program to study comparative population growth, using the United States and Mexico
SMOG - A simulation of smog generation by automobiles, and the effect of varied atmospheric conditions on this generation.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Digital Equipment Corporation

AVAILABILITY: DIGITAL

Huntington 1 Simulation Programs - Social Studies

DESCRIPTION: A booklet containing a variety of BASIC simulation programs for use in social studies.

BALANC - A program to demonstrate the distinction between "balance of trade" and "balance of payments", as well as the components that make up the "balance of payments" and their individual impacts.

BANK - A program to aid students in learning terms used in financial problems involving installment buying, long-term loans, and savings accounts. Emphasis on the mathematical logic behind the solution of financial problems.

CIRFLW - "Circular Flow Between Business and Consumer". A simulation of the circular flow of goods, services, and money between business and the consumer in a free enterprise economy without government control.

CONSMP - "Depression/Equilibrium" - A simulation to demonstrate: a) depression or recession results when consumption drops below the capacity to produce; b) equilibrium results when consumption equals the capacity to produce; and, c) how a "time-lag" in the discovering a drop in consumption can cause "over-production".

STOCK - A simulation of stock market activities to aid the student in developing an understanding of its operations.

MINIMUM
EDUCATIONAL LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Huntington Computer Project
State University of New York
Stonybrook, New York

AVAILABILITY: DIGITAL

Huntington II Simulation Programs - Social Studies

DESCRIPTION: Individual teaching modules.

ELECT1-2-3 - Three-part simulation of historical
Presidential elections and electorate
attitudes.

MARKET - Game engaging two companies on one-
product competition.

MASPAR - Model of mass participation in deci-
sion making.

POLICY - As members of various pressure groups,
students formulate national policy.

POLSYS - As various community members, students
influence city government policy.

SAP - Statistical analysis package.

USPOP - U.S. population dynamics study.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Huntington Two Computer Project
State University of New York
Stonybrook, New York

AVAILABILITY: DIGITAL

ELAN-Elementary Linguistic Analysis

DESCRIPTION: A program demonstrating the use of the computer in language studies.

MINIMUM
EDUCATIONAL LEVEL: Secondary Schools

LANGUAGE: MACRO-8

DEVELOPED ON: 4K PDP-8
Teletype

DEVELOPED BY: W.D. Gilmour
Coxbridge House
Cosbridge, Glastonbury
Somerset, England

AVAILABILITY: DECUS

Basic Application Programs - Business/Social Studies

DESCRIPTION: Eight basic programs which demonstrate simple computer applications in business.

DEPRECIATE - Program showing how a piece of capital equipment depreciates according to three commonly used depreciation methods: straight line, sum of the years digits, and double declining balance.

FIFO - Program demonstrating the First-in, First-out (FIFO) method of inventory valuation.

INDIAN - A simple interest problem using the \$24 paid to the Indians for Manhattan in 1626 as a basis for calculation.

INT-1 - Program illustrating how interest accumulates using compound interest methods as compared to using simple interest.

- INT-2 - Program demonstrating interest compounding with regular deposits to a savings account.
- ROUND OFF - A program whose sole function is to round off decimal numbers.
- SORT-1 - A program to sort a list of numbers into a given pattern.
- SORT-2 - A second method of number sorting.

MINIMUM
EDUCATIONAL LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communications
Services.

Computer Problems for Business I

DESCRIPTION: Series of business problems dealing with comparative shopping, truth in lending, invoicing, mortgages, bank statements, net pricing, the gas squeeze, and budget forecasting.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: LeRoy Finkel
DYMEX
Menlo Park, California

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communications
Services.

Basic Application Programs - Mathematics I

DESCRIPTION: Sixteen programs for simple applications in
mathematics, including geometry, statistics,
algebra, and graphing.

- BASKT - Demonstrates exponential convergence using a bouncing ball's height and distance traveled.
- BICYCL - Deals with the formula Distance = Rate X Time.
- CAI-ADD - Simple addition drill and practice.
- CAI-AD2 - An extension of CAI-ADD.
- CONVRG - Calculates Pi (π) by means of inscribed and circumscribed polygons, as well as by using an infinite series.
- DRINKR - Solves a simple drinking/blood pressure relationship.
- ROOTS - Finds the roots of any function between -20 and 20.
- SETS-1 - Determines the intersection of two sets of numbers.
- SIMUL - Solves simultaneous equations by trial and error method.
- TICKET - Introduces concept of logical branching.
- AREA-1 - Solves for the area under a curve by equation.

- LADDER - Solves the "slipping ladder" problem by the Pythagorean theorem.
- GUESS - Introduces student to binary search method by playing a number guessing game.
- SLOTS - Simulates a slot machine to introduce probability.
- DIAMON - Plots an N by N diamond matrix.
- PLOTFN - Plots any function.

MINIMUM

EDUCATION LEVEL: All

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE

INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communications
Services.

Basic Application Programs - Mathematics II

DESCRIPTION: Thirteen programs for applications in mathematics, including number theory, algebra, geometry, probability, and graphing.

BOOKS - Demonstrates method for solving simultaneous equations.

DISTANCE - Calculates distance between points in three-dimensional space.

EXPON - Solves for the exponent in general exponential equations.

- GOLDBACH - Tests Goldbach's Conjecture that every even number E greater than four is the sum of two odd prime numbers. Tests up to $E = 50$.
- GROUP - Demonstrates trial-and-error vs. substitutional methods of solving simple equations.
- PASCAL - Uses random numbers to generate Pascal's triangle.
- POGRS - Solves a number progression problem.
- QUADRT - Solves for the roots of a quadratic equation.
- TUTOR-1 - Drill and practice with time-speed-distance problems.
- CRSCNT - Solves for the area of a crescent.
- FLIP-1 - Flips a coin using the random number generator.
- SINEX - Plots a sine wave.
- 3DPLOT - Plots any three-dimension function.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

PUBLISHED BY: Digital Equipment Corporation (sources varied)

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communications
Services.

Problems for Computer Mathematics

DESCRIPTION: Approximately 80 problems ranging from simple to complex mathematical concepts.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Ronald Allison
Valley Stream North High School
Valley Stream, New York

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communication
Services.

Advanced Problems For Computer Mathematics

DESCRIPTION: A sequel to Problems for Computer Mathematics, 6.8.3.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Robert Albrecht
DYMEX
Menlo Park, California

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

Basic Matrix Operations

DESCRIPTION: Booklet describing methods involved in writing matrix operations in the Basic language.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Communications Services.

Computer Augmented Calculus Topics

DESCRIPTION: Deals with calculus applications and Basic programming.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Project SOLO
University of Pittsburgh

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communications
Services.

Huntington I Application Programs - Mathematics

DESCRIPTION:	Twenty programs useful for introducing simple mathematics concepts.
ARITH	- Review of multiplication skills. (General Math)
BANK	- Solves financial problems concerning installment buying, long-term loans, and savings accounts.
CRVLEN	- Computes the length of any curve (analytically defined).
GCD	- Finds the greatest common divisor of any set of numbers.
LIMSIN	- Evaluates the limit of $\sin x/x$ as x approaches zero, in both radian and degree measure.
PI2	- Computes the area of a circle using both inscribed and circumscribed regular polygons.
PLOTTR	- Plots the graph of any function.
PRIFA	- Finds prime factors.
QUADRT	- Describes the graph of the second-degree equation, $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$
RATIO	- Solves for the unknown in a proportion.
ROOTS2	- Finds the real roots of the quadratic equation.
SETS	- Finds the union and intersection of any two numerical sets.
SIMEQN	- Finds solutions to sets of up to ten simultaneous equations.
SLOPE	- Computes the tangent slope for any function.
SQRT	- Finds the square root of counting numbers up to five decimal places.

STATAL - Calculates the arithmetic mean
(average) of a set of numbers.

STOCK - Simulates the stock market

SURFAR - Computes the area of any surface
of revolution.

VOLSOL - Finds the volume of solids of
revolution.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Huntington Computer Project
State University of New York
Stonybrook, New York

PUBLISHED BY: Digital Equipment Corporation

AVAILABILITY: Software Distribution Center
Consult Curriculum Material Product Catalog
for pricing.

FOR MORE
INFORMATION: See Curriculum Material Product Catalog,
available from Digital's Communications
Services.

Mathematics - Set 4

DESCRIPTION: Five mathematics programs from varied sources:

WKSHT1 - A program to generate worksheets
for factoring trinomials or
multiplication of binomials.

SKSHT2 - A program to generate worksheets
for solving equations of the form
 $AX + B = CX + D$, where X is an
integer.

LISSAJOUS - A program to plot the graph of
FIGURES two time-dependent sinusoidal
functions, one in X and one in Y,
on a single Cartesian coordinate
system.

- TRIAD - a program to determine the numerical values for corresponding parts of triangle ABC.
- POLFAC - A program to find the integral and/or rational zeroes of any sixth degree polynomial or less, where the first and last terms' coefficients are integers.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Sources Varied

AVAILABILITY: DECUS

Mathematics - Set 5

DESCRIPTION: Seventeen programs, including:

STNDEV - Calculates the mean, biased and unbiased variance, biased and unbiased standard deviation, and standard error for a set of numbers.

PRIME - Determines if number N is a prime number.

TABLE - Table of values of sine and cosine functions from 0 to 90.

PERMS - Prints all permutations of N letters.

DIVIDE - A simple exercise in division.

DERIV - Calculates approximations to the derivative.

CONTOURS - Demonstrates the level curves (contours) of a function of two variables.

MAX	- Finds the maximum value of a function on an interval.
CHINES	- Solves N simultaneous congruences of the form: $Z \cdot X$ congruent to B (MOD M).
EUCLID	- Finds the greatest common divisor of two integers, together with the weighting factors by which the GCD is expressible as a linear combination.
SIEVE	- Demonstrates the sieve method of finding primes.
FRSQRS	- Writes positive integers as the sum of 4 squares.
INSCRB	- Prints first ten Pythagorean triangles and the radius of the inscribed circle of each.
FACTAP	- Computes factorials by Stirling's formula.
EASYØ2	- Lists factors for a given number N.
FACTRL	- Computes the sum of the first N factorials.
SPHERE	- Relationship of surface area, radius and volume of spheres.

MINIMUM EDUCATION LEVEL:	Secondary Schools
LANGUAGE:	Basic
DEVELOPED ON:	EduSystem 20
DEVELOPED BY:	Walter Koetke Lexington High School Lexington, MA.
AVAILABILITY:	DECUS

Mathematics - Set 6

DESCRIPTION: Eight programs from varied sources, including:

QTABLE	- Produces a table of values for all algebraic and many rational functions.
CORREL	- Calculates coefficient of linear correlation based on pairs of data supplied by the user.
INTEGR	- Approximates a definite integral by using a Riemann sum for a user-supplied function.
QUADEQ	- Will solve any quadratic equation in the form: $Ax^2 + Bx + C = 0.$
SIGDIG	- Raises any integer to any other integer and prints all significant digits.
EQUA	- Shows the step-by-step solution to an equation of the form: $AX + B = CX + D.$
SIMEQ2	- Solves any system of two linear equations in two unknowns.
SIMEQ3	- Solves any system of three linear equations in three unknowns.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Sources Varied

AVAILABILITY: DECUS

LIB12 - Mathematical and Graphing Routines

DESCRIPTION:

A series of twelve programs, including:

- UNPLOT - The user inputs, in octal form, three 12-bit (4-digit) numbers representing the high, middle and low words of the floating AC; the program returns with the equivalent decimal value.
- PERFCT - A fast program for finding perfect numbers with up to twelve digits of precision.
- SORTS - Three methods of sorting:
 - (1) TREES - a binary tree (heap) sort;
 - (2) TOP1 - a fast version of the "top" sort;
 - (3) TOP2 - slower, but it resembles the input order.
- CALEND - Prints a calendar for the current year. User inputs year (1969 or later).
- POLY - Brute force polynomial search and reducing. If and when quadratic level is reached, both roots (real or imaginary or complex) are calculated and printed.
- CUBIC - This program handles solutions of cubics and quadratics, but allows for possible upward expansion by the user.
- FRCAD - Adds fractions as fractions, finds L.C.D., and reduces answers to lowest terms.
- REPTER - A string of up to 6 digits, specified as repeating (9.0 repeating means 9.090909090...) or terminating (9.0 terminating is just 9), is converted to a proper or improper fraction reduced to lowest terms.

- SINCOS - Graphs sine and cosine curves.
- ELLHYP - Tangent ellipse/hyperbola, with asymptotes of the latter.
- POINTS - A series of graphs, on increasingly larger scales, of the hyperbolic curves of addition and cancellation of radiation from 2 point sources.
- HARMON - A series of curves successively approximating a sawtooth or a square wave (user choice).

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: DOM Geoffrey Chase
Portsmouth Abbey School
Portsmouth, Rhode Island

AVAILABILITY: DECUS

UB17 - Package of Mathematical Routines

DESCRIPTION: Routines for complex numbers, matrices and determinants, extended precision routines, and utility routines.

- CXEXP - Calculates complex powers of a complex number.
- FNCTS - Calculates trigonometric and hyperbolic functions of a complex variable.
- CXARTH - Performs complex vector arithmetic.
- INROOT - Prints the Nth roots of a complex number.
- SOLVIT - Solves n linear equations in n unknowns (Gaussian Reduction).

CRAMER - Program similar to SOLVIT, but more accurate.

DETERM - Triangularizes a square matrix and computes determinant.

INVERT - Prints inverse of an n by n matrix.

LARGNUM - Arithmetic for up to 100 digits.

10↑N - Powers of 10 presented as PDP-8 octal words.

POWERS - Shows powers of a given number in extended precision.

FIFTY! - Computes extended precision factorials up to 50.

PRIBET - Prints and counts prime numbers between limits.

FACTOR - Finds and counts prime factors.

NEWBAS - Converts number bases.

ARCSIN/
ARCCOS - Recursive subroutine to calculate arc sine and arc cosine.

FLOAT - Prints internal floating point PDP-8 representation of any legal BASIC number.

MINIMUM
EDUCATION LEVEL: Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: DOM Geoffrey Chase
Portsmouth Abbey School
Portsmouth, Rhode Island

AVAILABILITY: DECUS

STATPAC Revisions

DESCRIPTION:

Eleven programs from the original Dartmouth Basic Statistical Package which were revised for use on the PDP-8.

- STAT01 - Computes the mean, variance, standard deviation and standard error of the mean for one or more sets of data.
- STAT02 - Computes the means, variances, and T-ratio for two groups of unpaired data which have the same variance.
- STAT03 - Computes the means, variances, and T-ratio for two groups of unpaired data which may have unequal variances.
- STAT04 - Computes chi square statistics for 2 by 2 contingency tables.
- STAT08 - Compares two groups of data using the median test.
- STAT9X - Computes the slope and other statistics for a linear regression with several y values for each x value.
- STAT11 - Computes the Spearman rank correlation coefficient for two series of data.
- STAT20 - Multiple linear regression according to Efroyson's algorithm.
- STAT21 - Computes one or more multiple linear regressions on a set of data.
- RXC - Analysis of table with r rows and c columns.
- CORREL - Computes a correlation coefficient.

MINIMUM

EDUCATION LEVEL:

Secondary Schools

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Roger Strickland
Berkshire Community College
Pittsfield, MA.
(Revised from original Dartmouth Statistics
Package)

AVAILABILITY: DECUS

Butler Area School District Computer Mathematics Series

DESCRIPTION: A series of 26 mathematics programs for various age levels, in which provision is made for alternative questions on "retakes" at each level.

Some of the mathematics topics covered are:

- Addition of positive integers, with and without carrying
- Converting fractions to decimals and vice versa
- Percentage
- Geometric formulas
- Units of measure

The Achievement Ideograph Program gives explicit student achievement records for any program that has given pre- and post- tests. The program also calculates the expected and observed gain for each student and group average.

MINIMUM
EDUCATION LEVEL: All

LANGUAGE TSS/8 Basic

DEVELOPED ON: 12K TSS/8

DEVELOPED BY: Keith Henry, John Koehring, Albert Stewart
Guy N. Harriger Administration Building
167 New Castle Road
Butler, Pennsylvania 16001

AVAILABILITY: DECUS

Project DELTA - Mathematics Programs

DESCRIPTION:

Programs include:

- CROUT1 - Solves Simultaneous Linear Equations. This program solves m sets of $n \times n$ linear equations using the Crout algorithm with row interchange.
- SIMEQN - Solves Simultaneous Linear Equations. This program solves systems consisting of n linear equations in n unknowns.
- CDETER - Computes Value of Complex Determinant. This program computes the value of a complex determinant using the Crout method.
- CALC2 - Extended Precision Calculator. The program performs extended precision arithmetic operations on an imaginary accumulator, the contents of which are printed (with decimal point aligned) after each operation.
- FACTOR - Finds prime factors of positive integers.
- EUCLID - Computes largest common factor of two integers using the euclidean algorithm.
- DERIV - Derivative of a Function at a Point. This program gives a good approximation to the derivative of the function $FNF(X)$ at the point $x=a$, and shows successive difference quotients for values of x approaching a from the right.
- SQRS - Expresses an integer as the sum of four squares.
- SPHERE - Solves Spherical Triangles. This program solves spherical triangles having the apex at the North Pole and two other corners defined by their respective latitude and longitude.

- LRGNUM - Large Number Addition and Multiplication. This program will perform addition or multiplication.
- FNCTS - Computes Trig Functions for Complex Arguments. This program computes the values of SIN, COS, TAN, SINH, COSH, TANH for a complex argument of the form $z=a+ib$. The program will request the values of a and b (in radians) during execution, then print the real and imaginary parts of each function.
- SQUARZ - Computes Square Root of Complex Number. This program computes the square root of a complex number. It will request the real and imaginary parts of a complex number of the form $z=a+ib$.
- CURFIT - Performs Least Squares Fit. This program performs a least squares fit to the following functions:
1. $Y=A+B(x)$
 2. $Y=A \text{ EXP}(B*x)$
 3. $Y=A(x**B)$
 4. $Y=A+B/x$
 5. $Y=1/(A+B*x)$
 6. $Y=x/(A+B*x)$
- Input required is the number of data pairs and each data pair. For each function, details for that particular curve fit to your data are available.
- INTGRT - Computes Numeric Integral of a Function. This program uses Simpson's rule for finding the numeric integral of a function.
- ROMINT - Integrates a Function by Romberg Method. This program will integrate a given function by the Romberg method. Necessary input is the function, lower and upper limits of integration, and the order of integration.
- ROOTER - Finds the roots of a polynomial using Barstow's method.

BESSEL - Calculates Bessel Function. The program requests order, argument, and acceptable error and returns the computed value.

GFFT - Fast Fourier Transform. The program finds the Fourier transform of a function by evaluating the formula:

$$F(n) = \frac{1}{N} \sum_{i=0}^{N-1} F(i) e^{-j i n \frac{2\pi}{N}}$$

PLOT - Plots a Function on the User Terminal.

DEQFO - Solves First Order Differential Equations. This program solves the initial value problem for a first order differential equation by the second order Runge-Kutta method.

DQEOF2 - Solves Second Order Differential Equations. This program solves a second order differential equation by the second order Runge-Kutta method.

LINFIT - Best Linear Curve Fit Calculations. This program computes the best linear fit and correlation for a set of independent variables to a dependent variable. The final equation has the form:

$$Y = A_0 + A_1 X_1 + \dots + A_n X_n$$

where the A's are calculated by the program.

MINIMUM

EDUCATION LEVEL: All

LANGUAGE: Basic-Plus

DEVELOPED ON: RSTS-11

DEVELOPED BY: Project DELTA
University of Delaware
NEWARK, Delaware

AVAILABILITY: DECUS

Project DELTA - Additional Mathematics Programs

DESCRIPTION:

Programs included are:

- GLPSAL - two phase simplex method of linear programming
- TMFCEV - time function evaluation (engineering applications)
- CALC - calculator for numbers of up to 100 digits
- CXEXP - raise a complex number to a real or complex power
- GSIMEQ - solves simultaneous linear equations
- CXARTH - performs vector arithmetic operations
- POLY - finds polynomial to approximate a table of x-y data
- POLFIT - performs multiple regression/correlation analysis
- FREQ - finds number of data points (frequency) within limits; data can be in a file or from terminal
- RANDOM - generates random numbers with user-specified sample and population sizes
- ANVAR3 - computes analysis of variance table for a 2-way classification of variables design in which a single observation is made for each combination of levels.
- ANVAR4 - computes analysis of variance table for a 2-way classification of variables factorial design with replicated observations
- ANOVA - computes analysis of variance table for a 2-way classification of variables; data is entered cell by cell, down columns

MULTX	- performs a least squares curve fit to one of seven functions; operation is interactive at the terminal
POLSUB	- exercises students in polynomial subtraction operations
GINTLP	- solves linear programming problems with variables of values 1 and 0
SIPRAC	- exercises students in mathematical operations on signed numbers
KR20	- item analysis and Kuder-Richardson formula 20
DE10R	- solves a first order differential equation (Runge-Kutta)
DE20R	- solves second order differential equation (Runge-Kutta)
SUNSET	- computes Greenwich Mean Time (or other time) for sunrise and sunset given a particular week and a given latitude and longitude
WAVES	- plots effects of changing wavelength, amplitude and phase on two waves and their sum
SPCTRA	- plots optical absorption spectra of two species equilibrium mixtures
FACTRL	- produces any desired factorial and preceding factorials
SQRZ	- finds the square root of a complex number
BISQAR	- drill for students on squaring binomials

MINIMUM
EDUCATION LEVEL:

Secondary Schools

LANGUAGE:

Basic-Plus

DEVELOPED BY:

DSAA: Project DELTA
University of Delaware
Newark, Delaware

AVAILABILITY:

DECUS

XYPLOT, 3DGRAPH, PLOT-1

DESCRIPTION: Programs from varied sources to perform simple teletype or other terminal plots.

XYPLOT - Plots single valued functions of X with X on the vertical axis.

3DGRAPH - Graphs functions of two variables; each graph is plotted three times.

PLOT-1 - Plots integral values of a function.

MINIMUM

EDUCATION LEVEL: All

LANGUAGE: Basic

DEVELOPED ON: EduSystem 20

DEVELOPED BY: Sources varied

AVAILABILITY: DECUS

WATFOR-11 (Waterloo FORTRAN Compiler)

DESCRIPTION: WATFOR-11 is a fast in-core FORTRAN compiler.

WATFOR-11 provides specially-designed error messages at both compile and execution time.

WATFOR-11 is compatible with Digital's FORTRAN IV and FORTRAN IV-PLUS compilers and IBM 360 WATFOR.

MINIMUM

EDUCATION LEVEL: Secondary Schools

LANGUAGE: MACRO-11

DEVELOPED ON: RSX-11D

DEVELOPED BY: Waterloo Foundation for the Advancement of Computing (WATFAC), Waterloo, Ontario, Canada

AVAILABILITY: WATFAC
Waterloo, Ontario

\$600 per year, which includes distribution, documentation, telephone support and periodic updates.

Project DELTA - Data Processing Programs

DESCRIPTION:	STOPB	- simulates a simple digital computer with a defined machine language
	BRAIN	- simulates a simple digital computer with a defined machine language more complex than STOPB
	ADDRES	- prints addresses on labels
	SORT	- performs ascending or descending sort on simple ASCII file
	XREF	- Basic program listing and cross reference generator
MINIMUM EDUCATION LEVEL:	All	
LANGUAGE:	Basic-Plus	
DEVELOPED ON:	RSTS-11	
DEVELOPED BY:	DSAA: Project DELTA University of Delaware Newark, Delaware	
AVAILABILITY:	DECUS	

MONTGOMERY COUNTY PUBLIC SCHOOLS, ROCKVILLE, MARYLAND

1. Elementary School Subjects

- a. Operation Whole Numbers
- b. Project Perimeter
- c. Learning About Per Cents
- d. Word Search
- e. Expanding Numerals
- f. Sign-on Fractions

2. Junior High School Science

- a. Entry
- b. Measuring With the Vernier Caliper
- c. Alkanes I
- d. Alkanes II
- e. Solutions
- f. A Key to Identification
- g. Getting to Know the Computer

3. Senior High Mathematics

- a. Ratio and Proportion
- b. Dimensional Analysis
- c. Slope of the Line
- d. Geometry Testing
- e. Factoring
- f. Introduction to Vectors
- g. Geometry Testing

- h. Problem Solving
- i. Trigonometric Solutions of Right Triangles
- j. Perimeter-Area Investigation
- k. Volume-Area Investigation
- l. Car Ownership
- m. APL Remote Computing and Program Writing

4. Senior High School Chemistry and Physics

- a. Using the Oxidation Potential Table
- b. Writing Chemical Formulas
- c. Balancing Chemical Equations
- d. An Acid-Base Titration
- e. The Gas Laws
- f. Construction of a Lens
- g. The Force Between Charged Particles
- h. Motion in the Earth's Gravitational Field
- i. A One-Dimensional Elastic Collision
- j. The Area Under a Curve
- k. The Analysis of Laboratory Data

5. Other Subjects

- a. Fully Automatic Real-Time Computer Election (FARCE)
- b. Passe Compose of Certain Verbs Conjugated with Etre
- c. Latitude and Longitude
- d. Limit Dimensioning
- e. Limit Dimensioning of Mating Machine Parts

Materials Developed Elsewhere

<u>PROGRAM</u>	<u>SOURCE</u>
Physics	Florida State University
Preskills	University of Texas - Science
Scientific Notation	Research Associates, Inc.
Logarithms	
Punctuation	University of Texas - McGraw Hill
Science and Mathematics Modules	Kansas City Public Schools
Introduction to Decimals	
Density	
French Program	Brooklyn College of CUNY
	Brooklyn, New York
Science and Mathematics Modules	CAI Laboratory in Math and Science
Basic Computational Skills	Kansas City, Missouri
Metric System	
Science and Mathematics Modules	CAI Laboratory in Math and Science
Relative Error	Kansas City, Missouri
Introduction to Pressure	
Pressure Continued	
Earth's Changing Surface	
Introduction to Scientific	
Notation	
Decimal Skills	
Exponents	
Fractional Exponents	
Average Velocity	
Final Velocity	
Computation with Scientific	
Notation	
Population and Pollution	
Law of Exponents	
Frontiers Under the Sea	
Vectors	
Three Short Cuts in Multi-	
plication	
Area	
Volcanoes	
Chemistry	
Introduction to Functions	
F = ma	
Boyle's Law	
Charles' Law	
Extinct Animals	

<u>PROGRAM</u>	<u>SOURCE</u>
Divisibility Tests	
Ecology	
Relative VELOCITY	
Basic Skills Drills	
Gone Fishing	
Learner-Controlled Drill and Practice	IBM Corporation San Jose, California
Physics Simulations	IBM Corporation Yorktown Heights, New York
Fundamentals of Data Processing	IBM Corporation, SRI New York, New York
APL Programs in Physics, Chemistry and Math	Science Research Associates, Inc. Chicago, Illinois
Chemistry Study Modules	The University of Texas Austin, Texas

THE SCHOOL DISTRICT OF PHILADELPHIA - DIVISION OF INSTRUCTIONAL SYSTEMS

1. Sabre "A Systems Approach to Basic Reading"
2. Computer Assisted Mathematics Senior High School Program
3. VICS Providing Vocational Guidance Information in Phila. Schools

THE GROWTH OF CAI AT THE
UNIVERSITY OF ALBERTA

by

E.W. Romaniuk
Division of Educational Research Services
The University of Alberta
Edmonton, Alberta T6G 2G5

A Paper presented at the
Northwest Scientific Association Conference
May, 1974

The Division of Educational Research Services (DERS) at the University of Alberta has been involved in the field of computer-assisted instruction (CAI) since 1967. Initially the authoring language used was APL/360. Authoring was conducted via remote typewriter terminals connected to the University of Alberta's IBM 360/67 computing system. A number of drill and practice, tutorial, and simulation sequences were written using APL.

In the Spring of 1968 DERS took possession of an IBM 1500 Instructional Computing System. Although the IBM 1500 System can be considered old and relatively small by current computing standards, it is still one of the most sophisticated CAI systems in existence today. The 1500 System consists of an IBM 1130 base computing system with some extra hardware. A major feature of the 1500 System is the provision of rich student stations. Each student station can consist of the following combinations:

- a cathode ray tube (CRT) which can display 16 lines, with 40 characters per line, including subscripting and superscripting. Over 500 different characters (i.e., mathematical, Russian, Chinese, APL, etc.), as defined by the author, can be made available within any CAI course.
- an image projector which can display over 1000 addressable static frames of colored or black and white 16mm film.

All film resides on cartridges and is automatically threaded when placed in the projector.

- an audio unit which can play up to two hours of prerecorded messages per audio tape. If desired by the author, student verbal responses can also be recorded.
- a light pen to permit students to point at certain lit areas on the CRT.

The 1500 System was initially delivered to DERS with eight student stations. Over the years a number of additions and modifications have been made to the system. Hardware additions include thirteen complete student stations, magnetic tape units, and a disk system with larger storage capacity. Included in the initial system were the Coursewriter II (CWII) and MAT (Mathematical Algorithm Translator) authoring system. MAT, a subset of APL/360 has since been replaced by APL/1500 (McMurchie, et al, 1970).

A number of changes were made to the CWII authoring system and various author support facilities were also added. For example, with the initial CWII system, authors were often unable to do any sophisticated analysis of student responses. In cooperation with other IBM 1500 installations a number of the additions were made to the authoring system and this added a tremendous amount of power to the original version of CWII.

An authoring area that required a great deal of effort was the process of constructing graphic pictures for the CRT display. To construct graphics, authors were required to produce a series of multi-punched cards. Each hole in the card indicated a dot of light on the CRT. The series of light dots would then compose the picture graphic. It was very easy to mispunch one of the cards and thus distort the display. Because of the time required and the frustration encountered in the production of picture graphics, authors tended to stay away from using the graphic feature of the CRT. Two years ago McGinnis (1972) designed a technique which permits use of the light pen for drawing graphics on-line. The on-line graphics technique is easy to use. Now it takes only minutes to construct graphics that would have taken hours under the original authoring system. Authors now make extensive use of picture graphics in their course material. For purposes of adequate documentation we were forced to write a plotting routine that prints true screen-size hard copies of the picture graphics used on the system.

Once the course material has been programmed and tested we encourage authors to follow-up on their instructional design goals. Two special off-line programs are now available to help authors improve their course material. One program accepts the course source code and, on output, displays a linear sequence of screen displays as well as anticipated answers to questions posed to the students. The author needs only to scan these listings at his desk and note

errors in spelling, revisions to the list of anticipated answers, and other modifications. Once a group of students has taken any portion of the course, the same listing format is again provided to the author but with the added display of cumulative student responses to the various anticipated answers for each question.

A second performance analysis program permits authors to trace an individual student's path through a course. Thus, if a particular student appears to be having difficulty with any section of the course, the author can request a listing of that individual's performance. The student and the author can then meet and discuss the reasons for the student's responses. In this way it is hoped the author, if so required, can intervene to provide the student with any necessary individualized instruction. Through use of the student performance data listings the author is expected to improve the course until it is optimized.

To aid authors in the production of CAI course material, technical assistance is available from DERS at a no charge basis. This includes programming, debugging, consultation in CAI techniques, the writing of specialized routines, and the production of film and audio. Since a number of authors wish to do their own programming they can take a twelve hour CAI course that provides instruction in the use of Coursewriter II. This CAI course has reduced learning time by about fifty percent and, as well, relieved the DERS staff from the added workload of conducting Coursewriter workshops.

When the 1500 System was originally installed the basic objectives were to support research, demonstration and instruction. Only a bit of demonstration material was supplied along with the 1500 System. Consequently, with the staff that was available, initial emphasis was placed upon research into CAI. As more experience was acquired in CAI the time spent for purposes of demonstration and instruction increased rapidly. For the past few years a demonstration package has been available for viewing by persons who visit the CAI Centre. Because various educational levels are available in the demonstration, broad age and ability levels can be accommodated. The demonstration programs cover the areas of simulations, games, tutorial instruction, and drill and practice. About 2,000 persons per year now view the demonstration program.

The amount of course material has also grown quite rapidly. The regularly used courseware now totals about 175 hours of instruction. This represents the average time taken by students to complete the material contained in fourteen different courses. A good deal of our courseware was obtained through the interchange of material with other IBM 1500 System installations.

One of the courses, Cardiology, a twenty hour course taken by second year medical students, has just completed the fourth year of operation. Student reaction to CAI has been very favorable. Demand for reserved use of the 1500 System for instructional purposes in conjunction with scheduled

university credit courses has reached the point where we now have to occasionally refuse requests for new courses requiring large blocks of time.

The future of CAI at the University of Alberta looks bright indeed. At this time our hope is that adequate resources and personnel can be obtained to satisfy the needs of our users and potential users.

References

McGinnis, N.P., Macro-Graphics for the 1500 System. A Paper presented at the 1972 ADIS Conference, Quebec City, August, 1972.

McMurchie, T.D., Scott, E.K., and Lippert, H.K. Systems Memo: A Programming Language/1500, Systems Memo No. 8, CAI Center, Florida State University, Tallahassee, 1970.

Romaniuk, E.W. CAI at the University of Alberta: A Review and a Forecast. CIPS Computer Magazine, February, 1974, pp. 4-11.

BIBLIOGRAPHY

Bell, Norman T., Moon, Robert D., Teacher Controlled Computer Assisted Instruction, (Michigan State University). Paper presented to AERA Annual Meeting, Los Angeles, February 1969.

Canadian Teachers' Federation, Computer Uses In Instructional Programs, Bibliographies in Education No. 4, November 1969.

Conference on Teachers Edition, Continuing Education for Teachers - Issues and Strategies, Canadian Teachers Federation, May 1975.

Downey, L.W., Organizing A Province-Wide Educational System, A Draft Report For The Commission on Educational Planning, Human Resources Research Council, Edmonton, 1970.

Educational Technology Magazine, The Computer and Education, The Educational Technology Reviews Series.

Feldhusen, John F., and Szabo, M., A Review of Developments In Computer Assisted Instruction, Educational Technology, April 1969.

Feldhusen, J., Szabo, M., Computer-Assisted Instruction: A Brief Review of Research, Contemporary Education, April 1969.

Fritz, John, Instruction Resources, Commission on Educational Planning.

Glaser, Robert, Marino, Mary Louise, A Basic Reference Shelf On Programmed Instruction, A Series One Paper from ERIC at Stanford, California Institute for Communications Research, Stanford University, 1968.

Hallworth, H.J., Brahan, J.W., Hart, J., Hunka, S., Olivier, W., Computer-Aided Learning In The Federal Republic Of Germany, Associate Committee On Instructional Technology, National Research Council of Canada, October 1974.

Hunka, S., Romaniuk, E.W., A Research And Development Proposal For The Establishment of a Computer-Assisted Instruction Facility, University of Alberta.

Hunka, S. Eight Years Of Computer-Assisted Instruction: Now What?
University of Alberta, February 1976.

Hunka, S. The Computer-Aided Instruction Activities of the Division of Educational Research Services at the University of Alberta,
University of Alberta, December 1972.

Hunka, S. Use Of APL Terminals In The Edmonton Public Schools, University of Alberta, March 1971.

Hunka, S. The Challenges of Computer Assisted Instruction in Systems for The 70's, Papers delivered at Canadian Conference on Business Education, Banff, Alberta, Published in Toronto by Sir I. Pitman, 1967.

Licklider, J.C.R., Discussant in Computers and the World of the Future, Cambridge, The M.I.T. Press, 1962.

McEwen, Nelly, Robinson, Arthur, Implementing Computer-Assisted Instruction In A Regular French Class, University of Alberta, June 1976.

McEwen, Nelly, Computer-Assisted Instruction In Second Language Learning, An Alberta Project, University of Alberta, May 1975.

Mitzel, Harold E., An Examination Of The Short-Range Potential Of Computer-Managed Instruction, The Pennsylvania State University.

Morgan, Catherine, Computer-Assisted Instruction Program, A Three Year Report Covering July 1, 1971 to June 30, 1974. Albert Einstein High School, Kensington.

Myers, Sheldon S., Three Educational Technologies: Computer Assisted Instruction, Instructional Television, Classroom Films. Educational Products Report, No. 43

Petruk, Dr. M.W., Effectiveness Of A CAI-Taught Electrical Theory Course For Training Electrical Apprentices, Alberta Advanced Education and Manpower, and Canada Manpower and Immigration.

Richardson, William M., Computer-Assisted Instruction Project, Covering Period from July 1, 1969 to June 30, 1971.

Riffel, J.A. Using Computer Technology In Education: A Mission Proposal, The Alberta Human Resources Research Council, 1970.

Romaniuk, E.W., CAI At The University Of Alberta: A Review And A Forecast, Division of Educational Research Services, University of Alberta.

School District of Philadelphia, Computers In The Instructional Program, Division of Instructional Systems.

Westrom, M., TAIM - The Teacher-Authored Instruction Manager: A Description, University of Alberta, October 1972.

Westrom, M., The Teacher-Authored Instruction Manager: Rationale, Description, and Initial Feasibility, University of Alberta, 1972.

